

What is claimed is:

1. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a plurality of carriers, said diversity receiver comprising:
 - an automatic gain control (hereinafter, referred to as an AGC) section which is provided for each branch and controls a gain of a tuner receiving said frequency division multiplexing signal to output an AGC value by the gain control;
 - a detector which is provided for each branch and detects said frequency division multiplexing signal obtained by said tuner;
 - a fast Fourier transformer which is provided for each branch and converts a detected output obtained by said detector, by using a fast Fourier transform, from a time domain into a frequency domain to output a carrier including a pilot signal;
 - an equalizer which is provided for each branch, equalizes a carrier obtained by said fast Fourier transformer by using a pilot signal and estimates the channel characteristic of the carrier;
 - a reliability calculator which is provided for each branch and calculates the reliability value of the carrier from a pilot signal outputted from said equalizer and an

AGC value outputted from said AGC section; and

a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier in accordance with the reliability value from said reliability value calculator.

2. A diversity receiver according to claim 1, wherein said reliability calculator includes:

a reliability value calculation section which is provided for each branch and calculates a reliability value of a carrier from a pilot signal outputted from said equalizer; and

a reliability value correction section which corrects the reliability value calculated in said reliability value calculation section by an AGC value from said AGC section, and

said carrier selecting/combining section performs one of selecting and weighting combining upon each carrier in accordance with a corrected reliability value in said reliability value correction section.

3. A diversity receiver according to claim 2, wherein

said reliability value correction section inputs an AGC value of said AGC section and a reliability value of said reliability value calculation section to a

predetermined correction table for each branch to correct said reliability value on the basis of said correction table.

5 4. A diversity receiver according to claim 2, wherein
said reliability value correction section excludes a
specified carrier by performing correction of reducing the
reliability value of the corresponding carrier to zero when
said carrier of a branch in which it is determined by an
10 AGC value from said AGC section that a received power is
lower than a predetermined reference value.

5. A diversity receiver which is formed of at least
two branches receiving a frequency division multiplexing
15 signal that a pilot signal is periodically inserted into a
plurality of carriers, said diversity receiver comprising:

an AGC signal which is provided for each branch and
controls a gain of a tuner receiving said frequency
division multiplexing signal to output an AGC value by the
20 gain control;

a detector which is provided for each branch and
detects said frequency division multiplexing signal
obtained by said tuner;

a fast Fourier transformer which is provided for each
25 branch and converts a detected output obtained by said

detector, by using a fast Fourier transform, from a time domain into a frequency domain to output a carrier including a pilot signal;

an equalizer which is provided for each branch,
5 equalizes a carrier obtained by said fast Fourier transformer by using a pilot signal and estimates the channel characteristic of the carrier;

a reliability calculator which is provided for each branch and calculates a reliability value of a carrier from
10 a pilot signal outputted from said equalizer and an AGC value outputted from said AGC section; and

a carrier selecting/combining section which excludes a carrier of a branch in which it is determined from the AGC value of said AGC section that the received power is lower
15 than a predetermined reference value, and performs one of selecting and weighting combining for each carrier by using the reliability value obtained from said reliability calculator when said received power is equal to or larger than the predetermined reference value.

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6. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a plurality of carriers, said diversity receiver comprising:

25 an AGC signal which is provided for each branch and

controls the gain of a tuner receiving said frequency division multiplexing signal to output an AGC value by the gain control;

a detector which is provided for each branch and
5 detects said frequency division multiplexing signal obtained by said tuner;

a fast Fourier transformer which is provided for each branch and converts a detected output obtained by said detector, by using a fast Fourier transform, from a time
10 domain into a frequency domain to output a carrier including a pilot signal;

an equalizer which is provided for each branch, equalizes a carrier obtained by said fast Fourier transformer by using a pilot signal and estimates the
15 channel characteristic of the carrier;

a comparator which compares said AGC values for branches and outputs a differential value between AGC values;

a reliability calculator which is provided for each
20 branch and calculates a reliability value of each carrier on the basis of a pilot signal outputted from said equalizer and the differential value between AGC values outputted from said comparator; and

a carrier selecting/combining section which performs
25 one of selecting and weighting combining upon each carrier

in accordance with the reliability value from said
reliability calculator.

7. A diversity receiver according to claim 6, wherein
5 said reliability calculator includes:

a reliability value calculation section which
calculates the reliability of each carrier by using the
pilot signal outputted from said equalizer; and

a reliability value correction section which corrects,
10 on the basis of a result of comparison by said comparator,
a reliability value from said reliability value calculation
section by said differential value between AGC values, and
said carrier selecting/combining section performs one
of selecting and weighting combining for each carrier in
15 accordance with the corrected reliability value from said
reliability value correction section.

8. A diversity receiver according to claim 7, wherein
said reliability value correction section inputs said
20 differential value between AGC values outputted from said
comparator and an output from said reliability value
calculation section to a predetermined correction table to
correct said reliability value on the basis of said
correction table.

9. A diversity receiver according to claim 7, wherein
said reliability value correction section excludes a
specified carrier by performing correction of reducing the
reliability value of a branch with relatively lower
5 received power to zero when said differential value between
AGC values outputted from said comparator is equal to or
larger than a predetermined threshold.

10. A diversity receiver which is formed of at least
10 two branches receiving a frequency division multiplexing
signal that a pilot signal is periodically inserted into a
plurality of carriers, said diversity receiver comprising:
an AGC signal which is provided for each branch and
controls a gain of a tuner receiving said frequency
15 division multiplexing signal to output an AGC value by the
gain control;

a detector which is provided for each branch and
detects said frequency division multiplexing signal
obtained by said tuner;

20 a fast Fourier transformer which is provided for each
branch and converts a detected output obtained by said
detector, by using a fast Fourier transform, from a time
domain into a frequency domain to output a carrier
including a pilot signal;

25 an equalizer which is provided for each branch,

equalizes a carrier obtained by said fast Fourier transformer by using a pilot signal and estimates the channel characteristic of the carrier;

a comparator which compares said AGC values for
5 branches to determine whether or not the differential value between AGC values is equal to or larger than a predetermined threshold, and outputs the result of comparison;

a reliability calculator which is provided for each
10 branch and calculates the reliability value of each carrier from a pilot signal outputted from said equalizer; and

a carrier selecting/combining section which, when it is determined that said differential value between AGC values outputted from said comparator is equal to or larger
15 than the predetermined threshold, excludes a carrier of a branch with relatively lower received power, and performs one of carrier selecting and weighting combining by using the reliability value from said reliability value calculator when said differential value is less than the
20 predetermined threshold.

11. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a
25 plurality of carriers, said diversity receiver comprising:

a detector which is provided for each branch and detects said frequency division multiplexing signal obtained by said tuner;

5 a fast Fourier transformer which is provided for each branch and converts a detected output obtained by said detector, by using a fast Fourier transform, from a time domain into a frequency domain to output a carrier including a pilot signal;

10 an equalizer which is provided for each branch, equalizes a carrier obtained by said fast Fourier transformer by using a pilot signal and estimates the channel characteristic of the carrier;

15 a C/N calculator which is provided for each branch and calculates a C/N value by using a carrier outputted from said equalizer;

a reliability calculator which is provided for each branch and calculates the reliability value of each carrier by using a pilot signal outputted from said equalizer and a C/N value outputted from said C/N calculator; and

20 a carrier selecting/combining section which performs one of selecting and weighting combining for each carrier in accordance with a reliability value from said reliability calculator.

25 12. A diversity receiver according to claim 11,

wherein

said reliability calculator includes:

a reliability value calculation section which is provided for each branch and calculates the reliability value of each carrier by using the pilot signal outputted from said equalizer; and

a reliability value correction section which corrects the reliability value from said reliability value calculation section on the basis of the C/N value from said C/N calculator, and

said carrier selecting/combining section performs one of selecting and weighting combining for each carrier in accordance with the corrected reliability value from said reliability value correction section.

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13. A diversity receiver according to claim 12,

wherein

said reliability value correction section inputs the C/N value from said C/N calculator and the reliability value from said reliability value calculation section to a predetermined correction table to correct said reliability value in accordance with said correction table.

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14. A diversity receiver according to claim 12,

25 wherein

said reliability value correction section excludes a specified carrier by performing correction of reducing the reliability value of a branch in which said C/N value is lower than a predetermined reference value to zero.

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15. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a plurality of carriers, said diversity receiver comprising:

10 a detector which is provided for each branch and detects said frequency division multiplexing signal obtained by said tuner;

a fast Fourier transformer which is provided for each branch and converts a detected output obtained by said
15 detector, by using a fast Fourier transform, from a time domain into a frequency domain to output a carrier including a pilot signal;

an equalizer which is provided for each branch, equalizes a carrier obtained by said fast Fourier
20 transformer by using a pilot signal and estimates the channel characteristic of the carrier;

a C/N calculator which is provided for each branch and calculates a C/N value by using a carrier outputted from said equalizer;

25 a reliability calculator which is provided for each

branch and calculates the reliability value of each carrier by using a pilot signal outputted from said equalizer; and

a carrier selecting/combining section which excludes a carrier of a branch in which a C/N value calculated in said

5 C/N calculator is lower than a predetermined reference value and, when said C/N value is higher than said predetermined reference value, performs one of selecting and weighting combining for each carrier in accordance with the reliability value from said reliability calculator.

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16. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a plurality of carriers, said diversity receiver comprising:

15 a detector which is provided for each branch and detects said frequency division multiplexing signal obtained by said tuner;

a fast Fourier transformer which is provided for each branch and converts a detected output obtained by said
20 detector, by using a fast Fourier transform, from a time domain into a frequency domain to output a carrier including a pilot signal;

an equalizer which is provided for each branch, equalizes a carrier obtained by said fast Fourier
25 transformer by using a pilot signal and estimates the

channel characteristic of the carrier;

a C/N calculator which is provided for each branch and calculates a C/N value by using a carrier outputted from said equalizer;

5 a comparator which is provided for each branch and compares said C/N values to output a differential value between said C/N values;

a reliability calculator which is provided for each branch and calculates the reliability value of each carrier
10 on the basis of a pilot signal outputted from said equalizer and a differential value between C/N values outputted from said comparator; and

a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier
15 in accordance with the reliability value from said reliability calculator.

17. A diversity receiver according to claim 16,
wherein

20 said reliability calculator includes:

a reliability value calculation section which is provided for each branch and calculates the reliability value of each carrier by using the pilot signal outputted from said equalizer; and

25 a reliability value correction section which, when it

is determined by said comparator that a differential value between C/N values exceeds a threshold, corrects said reliability value calculated by said reliability value calculation section by using said differential value
5 between C/N values, and

said carrier selecting/combining section performs one of selecting and weighting combining for each carrier in accordance with the corrected reliability value from said reliability value correction section.

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18. A diversity receiver according to claim 16,
wherein

said reliability value correction section inputs the differential value between C/N values obtained in said C/N
15 calculator and an output from said reliability value calculation section to a predetermined correction table to correct said reliability value in accordance with said correction table.

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19. A diversity receiver according to claim 17,
wherein

said reliability value correction section excludes a specified carrier by performing correction of reducing the reliability value of a branch with relatively inferior C/N
25 value to zero.

20. A diversity receiver formed of at least two
branches receiving a frequency division multiplexing signal
that a pilot signal is periodically inserted into a
5 plurality of carriers, said diversity receiver comprising:

a detector which is provided for each branch and
detects a frequency division multiplexing signal obtained
by a tuner;

a fast Fourier transformer which is provided for each
10 branch and converts a detected output obtained by said
detector from a time domain into a frequency domain by
using a fast Fourier transform to output a carrier
including a pilot signal;

an equalizer which is provided for each branch,
15 equalizes a carrier obtained by said fast Fourier
transformer by using a pilot signal and estimates the
channel characteristic of the carrier;

a C/N calculator which is provided for each branch and
calculates a C/N value by using the carrier outputted from
20 said equalizer;

a comparator which compares said C/N values for
branches outputted from said C/N calculator to output a
differential value between the C/N values;

a reliability calculator which is provided for each
25 branch and calculates the reliability value of each carrier

on the basis of a pilot signal outputted from said equalizer; and

a carrier selecting/combining section which excludes a carrier of a branch in which the C/N value is relatively inferior to a predetermined reference value when it is determined by said comparator that said differential value between C/N values is equal to or larger than a threshold, and when said differential value between C/N values is less than the threshold, which performs one of selecting and weighting combining upon each carrier in accordance with the reliability value from said reliability calculator.

21. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal, comprising:

an amplifier which is provided for each branch and amplifies said frequency division multiplexing signal;

a converter which is provided for each branch and extracts a plurality of carriers included in the frequency division multiplexing signal from said amplifier;

a demodulator which is provided for each branch and detects an output from said converter;

a reliability calculator which is provided for each branch and calculates a reliability value of each of said carriers by an output from said demodulator and an output

from said amplifier; and

a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier in accordance with the reliability value calculated in said
5 reliability calculator.

22. A diversity receiver which is formed of at least two branches receiving a frequency division multiplexing signal, comprising:

10 an amplifier which is provided for each branch, tunes said frequency division multiplexing signal and amplifies the same;

a mixer which is provided for each branch and converts radio frequency signal from said amplifier into an
15 intermediate frequency signal (hereinafter, referred to as an IF signal);

a detector which is provided for each branch and detects said IF signal outputted from said mixer to convert into a complex signal;

20 a time-frequency converter which is provided for each branch and converts a time domain signal from said detector into a frequency domain signal to output a carrier;

an equalizer which is provided for each branch and corrects the phase and amplitude of the carrier from said
25 time-frequency converter;

a reliability calculator which is provided for each branch and calculates the reliability value of said carrier by an output from said equalizer and an output from said amplifier; and

5 a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier in accordance with the reliability value calculated in said reliability calculator.

10 23. A diversity receiver having at least two branches receiving a frequency division multiplexing signal, comprising:

a reference value calculator which calculates, on the basis of a received signal power, a first reference value
15 for diversity and a second reference value for Viterbi decoding for each of said branches;

a first reliability calculator which calculates a first reliability value used for diversity for each branch by said first reference value;

20 a second reliability calculator which calculates a second reliability value used for Viterbi decoding for each carrier by said second reference value;

a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier
25 in accordance with said first reliability value for each of

said branches; and

a Viterbi decoder which weights an output from said carrier selecting/combining section with said second reliability value to perform maximum likelihood decoding.

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24. A diversity receiver having at least two branches receiving a frequency division multiplexing signal, comprising:

a reference value calculator which calculates, on the basis of a received signal power, a first reference value for diversity and a second reference value for Viterbi decoding for each of said branches;

a first reliability calculator which calculates a first reliability value used for diversity for each branch by said first reference value;

a second reliability calculator which calculates a second reliability value used for Viterbi decoding for each carrier by said second reference value;

a carrier selecting/combining section which performs one of selecting and weighting combining upon each carrier in accordance with the first reliability value for each of said branches, and performs one of selecting or combining said second reliability value in accordance with said first reliability value to convert into a third reliability value; and

a Viterbi decoder which weights a carrier outputted from said carrier selecting/combining section with said third reliability value to perform maximum likelihood decoding.

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25. A diversity receiver according to claim 24, wherein

said carrier selecting/combining section includes:

a carrier diversity section which performs one of
10 carrier selecting and weighting combining using a first calculation table in accordance with said first reliability value for each of said branches; and

a reliability value diversity section which performs one of selecting and combining said second reliability
15 value using a second calculation table in accordance with said first reliability value for each of said branches to convert into a third reliability value.

26. A diversity receiver having at least two branches
20 receiving a frequency division multiplexing signal in which a scattered pilot signal is periodically inserted into a plurality of carriers, said diversity receiver comprising:

a power calculator which is provided for each branch and calculates the channel characteristic of each carrier
25 by interpolating said scattered pilot signal in time and

frequency directions to calculate the power of the channel characteristic for each carrier;

a first average power calculator which is provided for each branch and calculates an average power PA for

5 diversity by using an output from said power calculator;

a second average power calculator which is provided for each branch and calculates an average power PB for Viterbi decoding by using an output from said power calculator;

10 a first reliability calculator which is provided for each branch and calculates a first reliability value for each carrier on the basis of said channel characteristic power for each carrier with said average power PA serving as a reference;

15 a second reliability calculator which is provided for each branch and calculates a second reliability value for each carrier on the basis of said channel characteristic power for each carrier with said average power PB serving as a reference;

20 a carrier diversity section which performs one of selecting and weighting combining upon each carrier in accordance with said first reliability value for each branch;

a reliability value diversity section which performs
25 selecting and combining said second reliability value in

accordance with said first reliability value for each
branch to calculate a new third reliability value; and

a Viterbi decoder which weights an output from said
carrier diversity section with said third reliability value
5 to perform maximum likelihood decoding.

27. A diversity receiver according to claim 26,
wherein

said carrier diversity section performs one of
10 selecting and weighting combining for each carrier in
accordance with a first calculation table using said first
reliability value for each branch, and

said reliability value diversity section performs one
of selecting and combining said second reliability value in
15 accordance with a second calculation table using said first
reliability value for each branch to calculate a new third
reliability value.

28. A diversity receiver according to claim 26,
20 wherein

said first average power calculator calculates the
average power P_A for diversity by using the channel
characteristic outputted from said power calculator, and

said second average power calculator calculates the
25 average power P_B for Viterbi decoding by using the channel

characteristic outputted from said power calculator.

29. A diversity receiver according to claim 26,
wherein

5 said first average power calculator calculates an
average power by average calculation which takes longer
time than that in said second average power calculator.

30. A diversity receiver having at least two branches
10 receiving a frequency division multiplexing signal in which
a scattered pilot signal is periodically inserted into a
plurality of carriers, said diversity receiver comprising:

 a power calculator which is provided for each branch
and calculates the channel characteristic of each carrier
15 by interpolating said scattered pilot signal in time and
frequency directions to calculate the power of the channel
characteristic for each carrier;

 a first average power calculator which is provided for
each branch and calculates an average power PA for
20 diversity by using an output from said power calculator;

 a second average power calculator which is provided
for each branch and calculates an average power PB for
Viterbi decoding by using an output from said power
calculator;

25 a first reliability calculator which is provided for

each branch and calculates a first reliability value by said channel characteristic power for each carrier with an optionally set reference value A0 serving as a reference;

a second reliability calculator which is provided for
5 each branch and calculates a second reliability value for each carrier by said channel characteristic power for each carrier with said average power PB serving as a reference;

a carrier diversity section which performs one of selecting and weighting combining for each carrier in
10 accordance with said first reliability value for each branch;

a reliability value diversity section which performs one of selecting and combining said second reliability value in accordance with said first reliability value for
15 each branch to calculate a new third reliability value; and

a Viterbi decoder which weights an output from said carrier diversity section with said third reliability value to perform maximum likelihood decoding.

20 31. A diversity receiver according to claim 26,
wherein

said second average power calculator calculates the average power PB by an optional short time average.

25 32. A diversity receiving method formed of at least

two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a plurality of carriers, said method comprising the steps of:

outputting, for each branch, an AGC signal which

5 controls a gain of a tuner receiving said frequency division multiplexing signal;

detecting said frequency division multiplexing signal for each branch;

converting, for each branch, said detected output from
10 a time domain into a frequency domain by using a fast Fourier transform;

equalizing a carrier including a pilot signal obtained by said fast Fourier transform for each branch;

calculating the reliability value of each carrier by
15 said pilot signal for each branch;

correcting, for each branch, said reliability value on the basis of said AGC signal; and

performing one of selecting and weighting combining upon each carrier in accordance with said corrected
20 reliability value.

33. A diversity receiving method formed of at least two branches receiving a frequency division multiplexing signal that a pilot signal is periodically inserted into a
25 plurality of carriers, said method comprising the steps of:

outputting, for each branch, an AGC signal which controls a gain of a tuner receiving said frequency division multiplexing signal;

detecting said frequency division multiplexing signal
5 for each branch;

converting, for each branch, said detected output from a time domain into a frequency domain by using a fast Fourier transform;

equalizing a carrier including a pilot signal obtained
10 by said fast Fourier transform for each branch;

calculating the reliability value of each carrier by said pilot signal for each branch;

comparing said AGC signals to determine whether or not a result of comparison is equal to or larger than a
15 predetermined threshold;

correcting, for each branch, when said result of comparison is larger than the threshold, said reliability value on the basis of said AGC signal; and

performing one of selecting and weighting combining
20 upon each carrier in accordance with said corrected reliability value.

34. A diversity receiving method formed of at least two branches receiving a frequency division multiplexing
25 signal that a pilot signal is periodically inserted into a

plurality of carriers, said method comprising the steps of:

detecting said frequency division multiplexing signal
for each branch;

converting, for each branch, said detected output from
5 a time domain into a frequency domain by using a fast
Fourier transform;

equalizing a carrier including a pilot signal obtained
by said fast Fourier transform for each branch;

calculating the reliability value of each carrier by
10 said pilot signal for each branch;

calculating a C/N value by said equalized output for
each branch;

correcting said reliability value by said C/N value
for each branch; and

15 performing one of selecting and weighting combining
upon each carrier in accordance with said corrected
reliability value.

35. A diversity receiving method formed of at least
20 two branches receiving a frequency division multiplexing
signal that a pilot signal is periodically inserted into a
plurality of carriers, said method comprising the steps of:

detecting said frequency division multiplexing signal
for each branch;

25 converting, for each branch, said detected output from

a time domain into a frequency domain by using a fast Fourier transform;

equalizing a carrier including a pilot signal obtained by said fast Fourier transform for each branch;

5 calculating the reliability value of each carrier by said pilot signal for each branch;

calculating a C/N value by said equalized output for each branch;

comparing said C/N values of said branches;

10 determining whether or not said result of comparison exceeds a predetermined threshold and, when said result exceeds said threshold, correcting said reliability value in accordance with said result of comparison for each branch; and

15 performing one of selecting and weighting combining upon each carrier in accordance with said corrected reliability value.

36. A diversity receiving method having at least two
20 branches receiving a frequency division multiplexing signal that a scattered pilot signal is periodically inserted into a plurality of carriers, comprising the steps of:

calculating the channel characteristic of each carrier by interpolating said scattered pilot signal in time and
25 frequency directions and calculating the power of the

channel characteristic for each carrier;

calculating an average power P_A for diversity for each branch;

calculating an average power P_B for Viterbi decoding
5 for each branch;

calculating, for each branch, a first reliability value of each carrier by said channel characteristic power for each carrier with said average power P_A serving as a reference;

10 calculating, for each branch, a second reliability value of each carrier by said channel characteristic power for each carrier with said average power P_B serving as a reference;

performing one of selecting and weighting combining
15 upon each carrier in accordance with said first reliability value for said each branch;

performs one of selecting and combining said second reliability value in accordance with said first reliability value for said each branch to calculate a new third
20 reliability value; and

weighting a carrier subjected to said one of selecting and weighting combining with said third reliability value and performing maximum likelihood decoding.

25 37. A diversity receiving method having at least two

branches receiving a frequency division multiplexing signal that a scattered pilot signal is periodically inserted into a plurality of carriers, comprising the steps of:

calculating the channel characteristic of each carrier

5 by interpolating said scattered pilot signal in time and frequency directions and calculating the power of the channel characteristic of each carrier;

optionally setting, for each branch, a reference value A0 for diversity;

10 calculating, for each branch, an average power PB for Viterbi decoding;

calculating, for each branch, a first reliability value for each carrier by said channel characteristic power for each carrier with said reference value A0 serving as a
15 reference;

calculating, for each branch, a second reliability value for each carrier by said channel characteristic power for each carrier with said average power PB serving as a reference;

20 performing one of selecting and weighting combining upon each carrier in accordance with said first reliability value of each branch;

performing one of selecting and combining said second reliability value in accordance with said first reliability
25 value of each branch to calculate a new third reliability

value; and

weighting a carrier subjected to said one of selecting and weighting combining with said third reliability value to perform maximum likelihood decoding.